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Study of the different levels of physicochemical and microbial spirulina (*Arthrospira platensis*) on quality of soufflé

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Abstract
In the last few years, microscopic organisms have attracted people and scientist from all over the world because of their various properties. Spirulina has found wide application is the mean of agriculture, food, pharmaceuticals, perfumeries, medicine and science. Now days this organism is used as a food supplement and markets in the form of pills, capsules and powder or incorporated into various types of food like cakes, biscuits, noodles, and health drink etc. Spirulina contain 60-70% protein much more than any other food in the world and tagged "Superfood". It also contain very high mineral (8%), dietary fibre (7%) and very low in fat (2.2%). Soufflé is a light airy cake of international reputation. It occupies first position in France among bakery foods. The study was conducted to standardize the protocol of soufflé cake and to enhance the nutritional value by spirulina. Five treatments T_0, T_1, T_2, T_3 and T_4 were used in ratio 0%, 4%, 6%, 8% and 10% of eggs solids, sugar, corn flour and dry fruit making soufflé cake. The mixture was baked in baking oven at 190˚C for 30 minutes. Best recipe was selected on the basis of sensory evaluation. The nutritional composition of Spirulina powder, development of Spirulina based value added products and their nutritional composition and shelf life. Value added biscuits were prepared by using refined wheat flour, sugar powder, ghee, milk, ammonia, baking powder, custard powder, milk powder, vanilla and pineapple essence and 10% levels of Spirulina powder. All possible usage of Spirulina platensis in human food including beverages, bakery products, candy, gel desserts, dairy and confectionary are introduced. Thus the study revealed that the developed soufflé cake was found to be rich in protein. The treatment T_3 was found best product and highly acceptable.

Keywords: eggs solids, sugar, corn flour, dry fruit and Spirulina

1. Introduction
The diet of humans has changed a few times since they first walked on the earth. For most of the time man gathered the seasonal foods - roots, fruits and seeds available within an hour's walking distance and they hunted and fished; the only food intake was fresh Spirulina is a nutrient rich super food for super health. Super foods can be defined as foods that have health promoting benefits and disease preventing properties over and above their usual nutritional value. Spirulina is the common name for human and animal food supplements produced primarily from two species of Cynobacteria, that is, *Arthrospira platensis* and *Arthrospira maxima*. Spirulina has many therapeutic properties such as hypocholestrolemic, immunological, antiviral and antiglutagenic effects (Mark, 2007) [19].
Spirulina is an excellent source of protein. Today, food is lower in essential nutrients than foods produced 50 years ago. Farming practices have depleted our soil fertility. Stress from environmental pollutants and lifestyle demands have increased our dietary requirements for certain essential nutrients. To overcome these problems, some super foods like aloevera, garlic, tomato, walnut, blue green algae (spirulina) have been introduced. Spirulina, Blue green algae (fusiformis) is being used as nutrient dense food materials in natural and health foods. It also has some potent nutrients and probiotic compounds that enhance health condition (Shrilaxmi, 2001).
Interest in food application of micro algae has its origin on three counts. Firstly, in certain countries a small section of the population has been eating naturally grown algae harvested from lakes etc. without ill effects for centuries (Becker, 1986) [21]. Secondly, the focus on protein calorie malnutrition in the third world countries was drawn by the FAO in sixties, which led to identification of newer protein source, particularly algae (Anonymous, 1963).
Spirulina is a nutrient dense food. It is particularly rich in proteins and also contains carotenoids, vitamins, minerals and essential fatty acids (Khan, 2005) [20].

It contains

Table 1

Protein	**55-70 %**
Carbohydrates	15-25 %
Moisture	6-7 %
Minerals	8-13 %
Fat	3-7 %
Fiber	8-10 %

The exact origin of spirulina is still unexplained, but it is known to have appeared 3.6 million years ago as an evolutionary bridge between bacteria and green plants. Spirulina is not only good for people, animals and plants thrive on it too. When given Spirulina, old cats and dogs

with dull, thinning coats have been seen to develop thick, lustrous coats; and pets with stiff joints appear to improve considerably, becoming supple and active again. Veterinarians prescribe Spirulina to aid recovery, increase stamina, relieve stiffness, and also for show animals for general toning, as these animals need to look their best (Henson, 1990).

Spirulina is about 60 % protein, far more than any other food. Its protein is complete, means, that it contains all the essential amino acids. While most animal proteins are high in fat, calories, and cholesterol, Spirulina has only 5% fat, most of which is beneficial unsaturated fatty acids like GLA (Gamma Linoleic Acid). There are less than four calories in each gram and practically no cholesterol. All possible usage of Spirulina platensis in human food including beverages, bakery products, candy, gel desserts, dairy and confectionary are introduced. S. platensis can be added to many drinks including health drink, sour milk and green tea in order to enhance their nutritional value. This microalgae powder can be added to improve the nutritional value of bread. Microalgae bread has color and flavor of algae and higher amounts of vitamins, microelements, especially the active biological material. Microalgae improved the water holding in the bread and cause to the long-term shelf time of product. Cookies are one kind of bakery products which due to the taste, appearance, texture, ease of preparation and storage have an important place in people's eating habits and are used widely.

Bakery product soufflé is a light, airy cake that originated in France and many people, such as (Claiborne and Franey, 1976) who wrote Soufflé Infinite Variations on a Sublime Theme regard it as “one of the great miracles of the French kitchen”. It is a corner stone of French cuisine, especially in the dessert department; however, soufflé can be both a dessert and a savory main dish. It comes from the word souffler, a French verb that means to ‘blow up’ or ‘puff up’, according to Claiborne and Franey. Soufflés always contain two elements: a pudding or crème patissiere base, and a merengue made of egg whites. When the two are folded together, they create a light, flavorful dish. Soufflé is by definition a wheat free dessert, because it does not contain any wheat flour or grain at all. It is eggy and somewhat resembles angel food cake, but even lighter. Soufflés, when made into desert, often have a sauce that is poured into the middle of them. When made savory style, they often contain interesting ingredients like onion, crab, or cheese. Like many French dishes, soufflé is meant to impress. It is beautiful, light and puffy, and takes a great deal of skill to master. Because of its grandeur, soufflé is not a food to be eaten for breakfast, brunch, or lunch. If made in the savory manner, it is usually eaten as an entree and if made sweet, is usually eaten after the main course for dessert. Most often, soufflé is made for special occasions (such as birthdays or anniversaries) or at up-scale, five star restaurants. Its simple perfection allures dinners of all kinds, and few can deny the deliciousness of a perfectly prepared soufflé. It is the neural correlates of these PPEs (Pseudo reward Prediction Errors) that form the focus of (Ribas Fernandes *et al*., 2011).

Material and Methods

The present investigation was carried out in Warner college of Dairy Technology Laboratory, SHUATS, Allahabad. Eggs, Corn flour, Dry fruits, Spirulina powder, Sugar were procured from the local market of Allahabad.

Treatment Combinations (In Percent)

Table 2

SL No.	Ingredients	T1	T2	T3	T4
1.	Eggs solids	40 %	40 %	40 %	40 %
2.	Sugar	20 %	20 %	20 %	20 %
3.	Corn flour	26 %	24 %	22 %	20 %
4.	Dry fruit	10 %	10 %	10 %	10 %
5.	Spirulina	4 %	6 %	8 %	10 %
	Total	500g	500g	500g	500g

Chemical Analysis

- **Carbohydrate:** This was estimated by lane eynons method.
- **Protein:** The protein content of samples was determined by Kjeldahl procedure described in AOAC (1984).
- **Fat:** Fat content in the samples was estimated by Soxhlet extraction method (AOAC, 1984).
- **Ash:** This was estimated by muffle furnance (Ranganna, 1986).
- **Moisture:** Moisture content was determined as per AOAC (1984) method.

Flow Chart for Making Soufflé

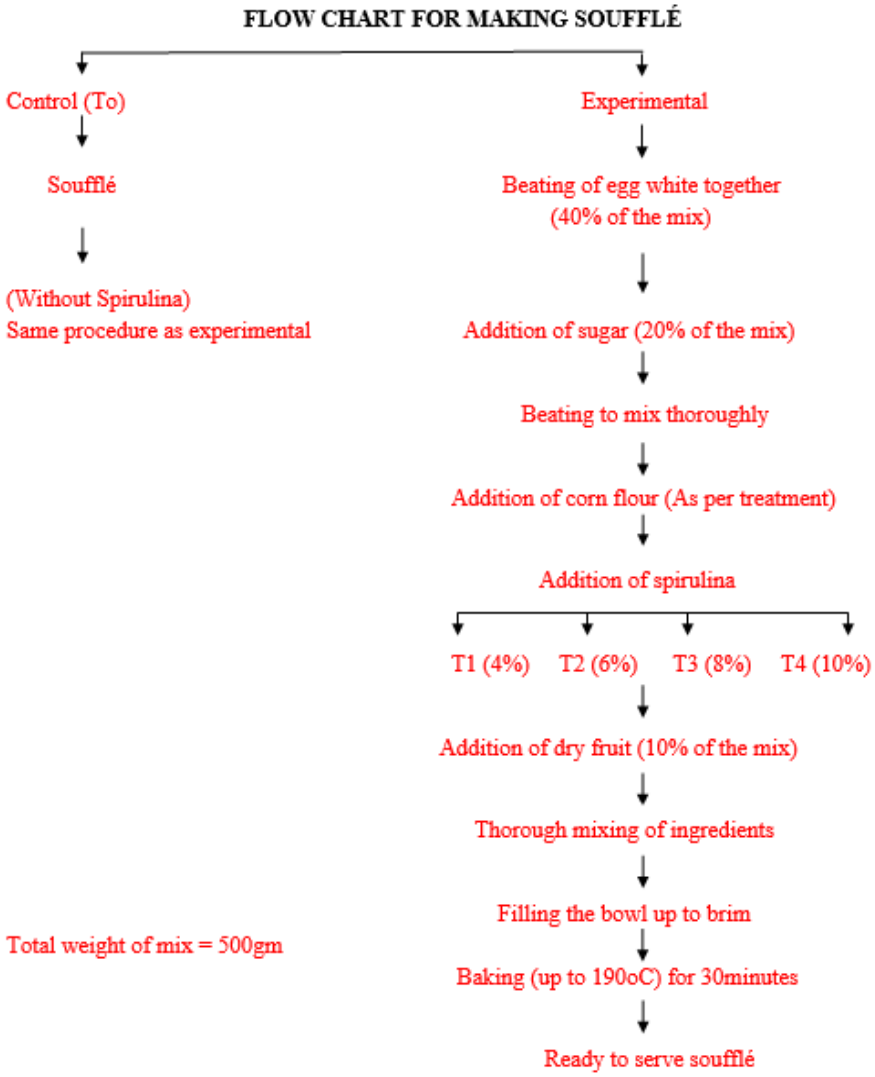

Fig 1

Table 3

Treatment	T0	T1	T2	T3	T4	C.D. Value
Carbohydrate %	73.52	71.83	71.50	70.26	68.14	0.55
Protein %	12.52	15.36	16.28	17.78	19.43	0.43
Fat %	1.68	1.88	2.14	2.60	2.96	0.18
Ash %	0.87	0.88	1.04	1.34	1.48	0.08
Moisture %	11.42	9.98	8.94	8.24	7.98	0.24
Colour & Appearance	7.87	7.72	7.92	8.13	7.13	0.18
Body & Texture	7.84	7.66	7.79	8.11	7.43	0.22
Flavour & Taste	7.63	7.58	7.98	8.21	7.16	0.31
Overall Acceptability	7.66	7.73	7.90	8.06	7.42	0.20

Chemical Characteristics of Control and Experimental Spirulina Soufflé

Average carbohydrate percentage of control and experimental spirulina soufflé

The highest mean score for carbohydrates percentage the Spirulina Soufflé (73.52) was obtained for the treatment T0 (control) followed by T1 (71.83), T2 (71.50) and T3 (70.26). The minimum score (68.14) was obtained by T4.

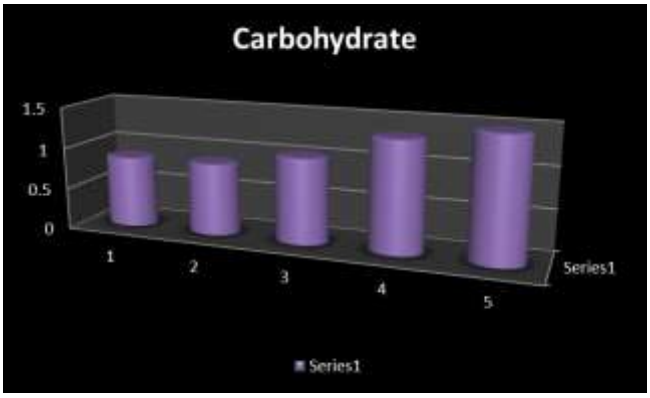

Fig 2: Percentage of carbohydrate in sample of control and experimental spirulina soufflé

Average protein percentage of control and experimental spirulina soufflé

The highest mean score for protein percentage the Spirulina Soufflé (19.43) was obtained for the treatment T4 followed by T3 (17.78), T2 (16.28) and T1 (15.36). The minimum score (12.52) was obtained by T0 (control).

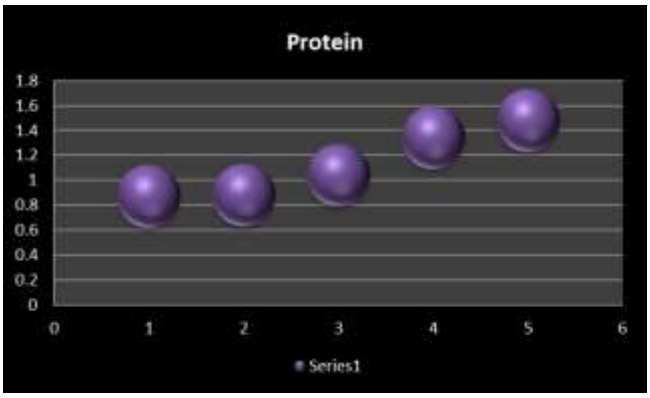

Fig 3: Percentage of protein in sample of control and experimental spirulina soufflé

Average fat percentage of control and experimental spirulina soufflé

The highest mean score for fat percentage the Spirulina Soufflé (2.96) was obtained for the treatment T4 followed by T3 (2.60), T2 (2.14) and T1 (1.88). The minimum score (1.68) was obtained by T0 (control).

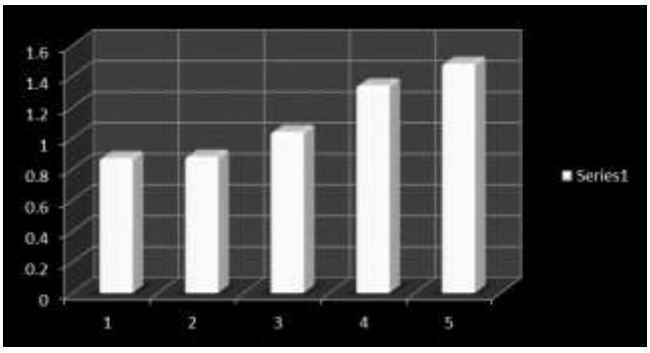

Fig 4: Percentage of fat in sample of control and experimental spirulina soufflé

Average ash percentage of control and experimental spirulina soufflé

The highest mean score for ash percentage the Spirulina Soufflé (1.48) was obtained for the treatment T4 followed by T3 (1.34), T2 (1.04) and T1 (0.88). The minimum score (0.87) was obtained by T0 (control).

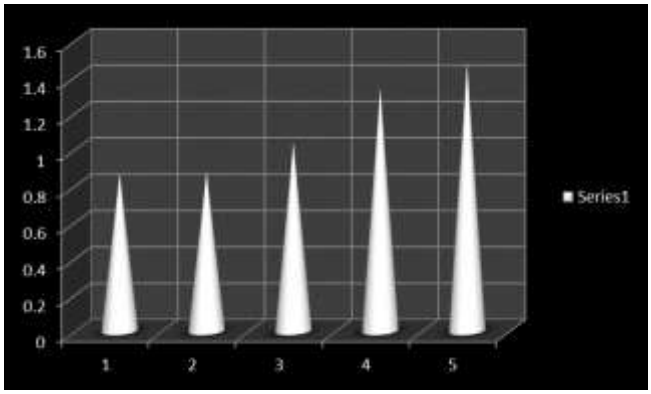

Fig 5: Percentage of ash in sample of control and experimental spirulina soufflé

Average moisture percentage of control and experimental spirulina soufflé

The highest mean score for moisture percentage the Spirulina Soufflé (11.42) was obtained for the treatment T0 (control). Followed by T1 (9.98), T2 (8.94) and T3 (8.24). The minimum score (7.98) was obtained by T4.

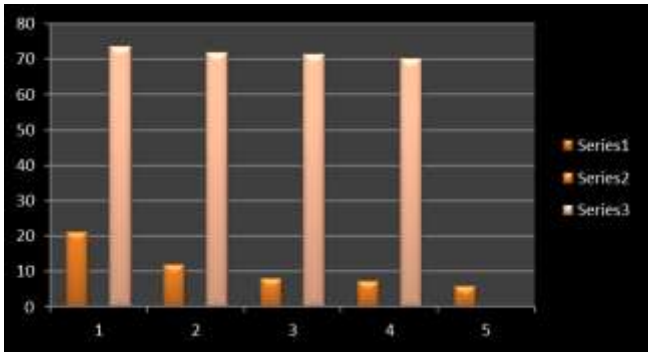

Fig 6: Percentage of moisture in sample of control and experimental spirulina soufflé

Average scores of the colour & appearance of control and experimental spirulina soufflé

The highest mean score for Colour and Appearance of the spirulina souffle (8.13) was obtained for the treatment T3 followed by T2 (7.92), T0 (7.87) and T1 (7.72). The minimum score (7.13) was obtained by T4.

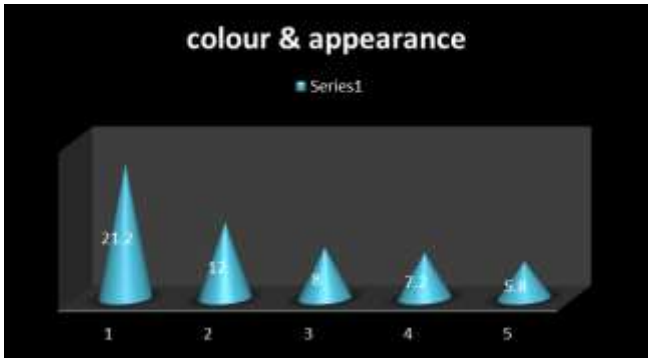

Fig 7: Score of colour and appearance in control and experimental spirulina soufflé

Average score of the body & texture of control and experimental spirulina soufflé

The highest mean score for Body and Texture of the Spirulina Soufflé (8.11) was obtained for the treatment T3 followed by T0 (7.84), T2 (7.79) and T1 (7.66). The minimum score (7.43) was obtained by T4.

Fig 8: Score of body & texture in sample of control and experimental spirulina soufflé

Average score of the flavour & taste of control and experimental spirulina soufflé.

The highest mean score for Flavour and Taste of the Spirulina Soufflé (8.21) was obtained for the treatment T3 followed by T2 (7.98), T0 (7.63) and T1 (7.58). The minimum score (7.16) was obtained by T4.

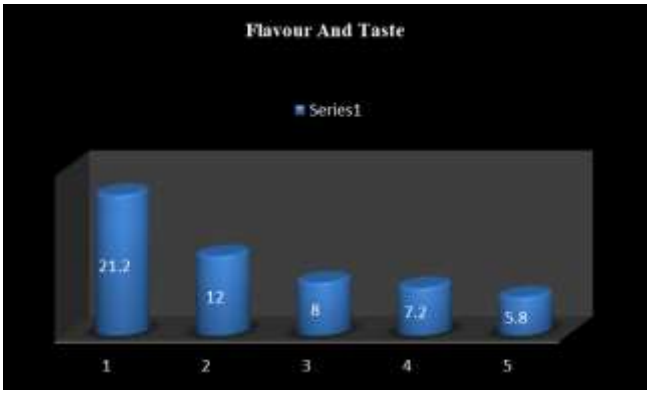

Fig 9: score of the flavour & taste of control and experimental spirulina soufflé

Average scores of the overall acceptability of control and experimental spirulina soufflé

The highest mean score for Overall Acceptability of the Spirulina Soufflé (8.06) was obtained for the treatment T3 followed by T2 (7.90), T1 (7.73) and T0 (7.66). The minimum score (7.42) was obtained by T4.

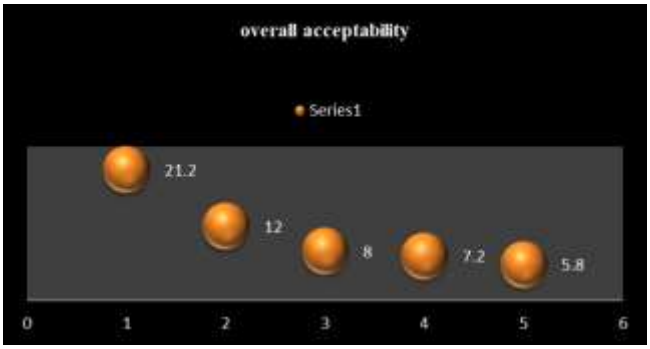

Fig 10: Score of the overall acceptability of control and experimental spirulina soufflé

Average scores for SPC (x103) cfu/gm of control and experimental spirulina soufflé

The highest mean score for SPC percentage the Spirulina Soufflé (25.40) was obtained for the treatment T0 (control) followed by T1 (16.40), T2 (11.40) and T3 (9.60). The minimum score (8.60) was obtained by T4.

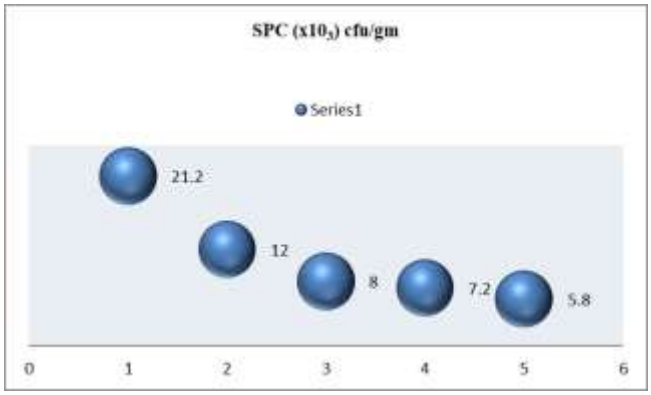

Fig 11: SPC in sample of control and experimental spirulina soufflé

Average scores of Yeast and mould count (x101) cfu/gm of control and experimental spirulina soufflé

The highest mean score for Yeast and Moulds of the Spirulina Soufflé (21.20) was obtained for the treatment T0 followed by T1 (12.00), T2 (8.00) and T3 (7.20). The minimum score (5.80) was obtained by T4.

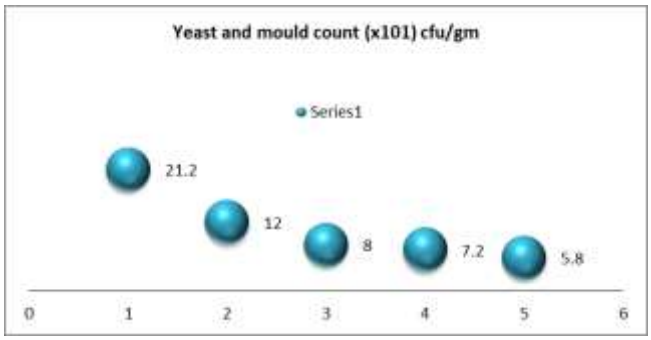

Fig 12: Yeast and mould in sample of control and experimental spirulina soufflé

Conclusion

Spirulina is a marine blue-green algae which are being expansively considered as the biomass of these microalgae and the compounds they manufacture have been exposed to have power over more than a few biological applications with several health benefits. Apart from being used as nutraceutical food supplement universal, it shows therapeutic reimbursement on an array of diseased conditions including hypercholesterolemia, hyperglyceridemia, cardiovascular diseases, inflammatory diseases, cancer and viral infections. Spirulina is also incorporated as a functional ingredient in food products and beverages. In recent years, spirulina has attracted scientific attention, not only for its various health benefits but also at a micro level of understanding the mechanisms of action of its various components. From being a 'complete' protein source, spirulina and its components have been exposed to have positive benefit across a range of human health

indications from malnutrition to antioxidant properties. Spirulina provides essential fats (e.g., gamma-linolenic oleic acids), concomitant to low content nucleic acids. It also has an unusually high comfortable of vitamin B12, is a superior resource of beta-carotene, iron, calcium and phosphorous. Moreover, Spirulina has also demonstrated to have high-quality recognition as of its organoleptic properties (thus making it a possible prospect for food or a nourishment enhancement) and it has exhibited neither acute nor chronic toxicities, production it protected for individual utilization. Taking the experimental results of the present investigation into considerations, it can be concluded that the Spirulina Soufflé prepared by incorporating the 8% spirulina powder extract i.e., Treatment 3 (T_3) outlaid the better organoleptic properties viz, Colour and Appearance, Body and Texture, Flavour and Taste and Overall Acceptability followed by treatment 2 (T_2) i.e., with 6% spirulina powder extract. The physico-chemical analysis results shows that treatment 4 (T_4) with 10% spirulina powder extract possess maximum moisture, protein, ash content, Antioxidant Activity while the control sample (T_0) has minimum Fat content. All the nutrients were in prescribed range. The microbial count was found to be within the limit. There was significant difference between and within the treatments.

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